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Inter-hemispheric synchrony of Holocene mid-latitude atmospheric circulation changes inferred from speleothem geochemical proxies

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Speleothems are valuable archives of past climatic and environmental conditions on the continents. Major strengths include their suitability for accurate U-series age determinations and their preservation of multiple quasi-independent climate proxies, e.g. stable isotopes, trace elements, mineralogy, textural features, as well as organic proxies. Furthermore, speleothem climate-proxy time series not only enable the reconstruction of past regional climate variability, but also through their global occurrence, an assessment of the extent to which such variability may be synchronous or asynchronous on various spatial scales; in turn providing insights into the climate forcing mechanism(s). We present a new inter-hemispheric comparison of two speleothem climate-proxy time series from Spannagel cave (47.08 °N), Austria, and Botuverá cave (27.22 °S), Brazil. These highly correlated ($r=-0.73$, $p<0.01$) proxy time series are sensitive to changes of the respective continental hydrological cycle and to changes of the respective hemispheric mid-latitude atmospheric circulation.

Both climate-proxy time series indicate wetter and drier climates and show that during the Holocene, major hydrological patterns changed synchronously. During the early Holocene, from 10 ka BP until about 7 ka BP, the speleothem proxy time series from Spannagel cave reveal a generally wetter climate, while the data from Botuverá cave recorded a drier climate. In the mid-Holocene period from 7 to 4 ka BP, both speleothem proxy time series indicate opposing trends towards drier conditions at Spannagel and wetter conditions at Botuverá. In the late Holocene period (since 4 ka BP) the speleothem proxy time series from Spannagel and Botuverá show a stable average mode of hydrological conditions, which are drier at Spannagel and wetter at Botuverá compared to the early Holocene. Quasi-millennial variations of the hydrological conditions at Spannagel and Botuverá cave are superimposed on the general long-term shifts of the time series. In the early Holocene, the wettest and driest conditions at Spannagel and Botuverá cave, respectively, occurred at 7 ka BP; the period before was slightly drier (wetter) at Spannagel (Botuverá) cave. The 8.2 ka event is resolved in both time series indicating drier (wetter) conditions at Spannagel (Botuverá) cave, but the changes are modest compared to the long-term and other early Holocene changes. During the late Holocene the quasi-millennial changes are more distinct in the time series from Spannagel and Botuverá compared with the early Holocene and show alternating wetter and drier conditions. Overall, these two speleothem proxy time series document a remarkable synchrony of two different parts of the global hydrological cycle in the Northern and Southern Hemisphere.

The recorded changes of the hydrological conditions are associated with changes of the relative proportions of winter and summer rainfall in the case of Spannagel cave and with changes in precipitation that is derived primarily from extra-tropical sources or from the South American Monsoon System in the case of Botuverá cave. The long-term changes thought to be forced by the long-term insolation change during the Holocene, but other possible mechanisms such as global temperature contrasts will also be discussed.